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David Fichtenberg
Ad-hoc Association of Parties Concerned About the Federal
Communications Commission's Radiofrequency Health and Safety Rules
PO Box 7577
Olympia, WA 98507-7577

July 9, 1997

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The Secretary
Federal Communications Commission
1919 M. Street N.W. Room 222
Washington, DC 20554

In the Matter of) ET-Docket No. 93-62
) and in this docket pertaining to:
Guidelines for Evaluating the Environmental) - Report and Order FCC 96-326
Effects of Radiofrequency Radiation) - First Memorandum of Understanding
Order FCC 96-487

**Ex Parte Comments Pertaining to ET-Docket 93-62 Regarding
PETITIONS FOR RECONSIDERATION of Commission Rule & Order FCC 96-326,
and First Memorandum of Opinion and Order FCC 96-487**

with original and 1 copy submitted to the Secretary of the Commission
in accordance with 47 CFR § 1.1202, 1.1203, and 1.1206(a)
4th Ex Parte Submission

Dear Mr. Secretary,

Enclosed please find an original and 1 copy of an ex parte presentation pertaining to ET-Docket 93-62 and being submitted in accordance with 47 CFR § 1.1202, 1.1203, and 1.1206(a). Please assure these are put in the official record of this proceeding.

The presentation includes comments and copies of some footnoted documents with exhibit numbers which are:

#E101: Report commissioned by the Spectrum Management Agency of Australia from the Australian Commonwealth Scientific and Industrial Research Organization (CSIRO) on: Status of Research On Biological Effects and Safety Of Electromagnetic Radiation: Telecommunications Frequencies, by S.B. Barnett, June 1994.

No. of Copies of
List A-3-10

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#E102: Radiofrequency Radiation Exposure Standards, Australia and New Zealand, 100 kHz -300 GHz: A Case For Reducing Human Exposure Limits Based On Low-Level, Non-Thermal Biological Effects, by A. H. Doull, Australian Commonwealth Scientific and Industrial Research Organization (CSIRO) Health and Safety Adviser, and Dr. C. Curtain, CSIRO Honorary Research Fellow, January 1994

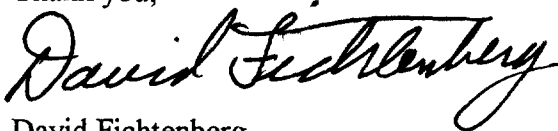
#E103: "Potential and Actual Adverse Effects of Radiofrequency and Microwave Radiation at levels near and below $2 \mu\text{W}/\text{cm}^2$," by Dr. Neil Cherry, Department of Natural Resources Engineering, Lincoln University, New Zealand, February 28, 1997

#E104: "Microwaving Our Planet: The Environmental Impact of the Wireless Revolution," by Mr. Arthur Firstenberg, 1996

#E86: Abstract of S. Kwee et al, "The Biological Effects of Microwave Radiation," given at the Second World Congress of Electricity and Magnetism in Biology and Medicine, in Bologna, Italy, June 8-13, 1997.

#E93: on some absorption characteristics of electromagnetic energy, from The New Encyclopedia Britannica, Vol. 18, 1991, pg. 198.

Thank you,



David Fichtenberg
Ad-hoc Association of Parties Concerned About the Federal Communications Commission's
Radiofrequency Health and Safety Rules
PO Box 7577
Olympia, WA 98507-7577 Tel: (206) 722-8306

July 9, 1997

Copy sent to:
Chairman Reed E. Hundt
Federal Communications Commission
1919 M Street, N.W. Room 814
Washington, D.C. 20554

Before the
FEDERAL COMMUNICATIONS COMMISSION

Washington, DC 20554

In the Matter of)	ET-Docket No. 93-62
)	and in this docket pertaining to:
Guidelines for Evaluating the Environmental)	- Report and Order FCC 96-326
Effects of Radiofrequency Radiation)	- First Memorandum of Understanding
		Order FCC 96-487

To: The Commission

**Ex Parte Comments Pertaining to ET-Docket 93-62
Regarding**

PETITIONS FOR RECONSIDERATION of Commission Rule & Order FCC 96-326,
and First Memorandum of Opinion and Order FCC 96-487
dated July 9, 1997

with original and 1 copy submitted to the Secretary of the Commission
in accordance with 47 CFR Section 1.1202, 1.1203, and 1.1206(a)

Submitted by the Ad-hoc Association of Parties Concerned About the Federal Communications
Commission's Radiofrequency Health and Safety Rules, PO Box 7577, Olympia, WA 98507-7577

1. Introduction:

1.1 Appropriate submission of an ex parte presentation

The Ad-hoc Association of Parties Concerned About the Federal Communications
Commission's Radiofrequency ("RF") Health and Safety Rules ("the Ad-Hoc Association")
understands (i) that a Federal Communications Commission ("Commission") "Sunshine Agenda"
period per 47 CFR Section 1.1202(f) and Section 1.1203 is not now in effect regarding ET-
Docket 93-62; (ii) that administrative finality has not yet been decided upon concerning the
Commission's responses to Petitions For Reconsideration that have been submitted in this
proceeding; and that (iii) this proceeding permits ex parte presentations in accordance with 47
CFR. § 1.1202, 1.1203, and 1.1206(a), and in accordance with the April 8, 1993 Notice of
Proposed Rule Making in ET-Docket 93-62, paragraph 30. Accordingly, the Ad-Hoc Association
is properly making this ex parte submission.

1.2. Purpose of this submission is to provide documentation, much of which has already been referenced by the Ad-Hoc Association or others in this proceeding, and which gives evidence supporting the petitions for reconsideration of FCC 96-326 and FCC 96-487 of the Ad-Hoc Association and other parties in this proceeding which are concerned that the Commission's rules in this proceeding may not be sufficiently protective of the public health.

To the extent that these comments rely on findings that were not previously presented to the Commission, these facts and reports became available and understood after the last opportunity for filing in this matter, excluding ex parte presentations, and in any event, consideration of these facts and comments significantly relates to changes needed for the public health and is in the public interest. In this way, the Ad-Hoc Association is providing an opportunity for the Commission to review and pass upon the matters presented herein, and by so doing the Commission will have the opportunity of considering any newly discovered evidence, and the Commission will also thus have the opportunity of reviewing objections not first raised previously and which support the requests in the Ad-Hoc Association FCC 96-326 and FCC 96-487 petitions, and in any event, even if the Commission find otherwise, the Commission's consideration and approval of Ad-Hoc Association requests is in the public interest. Should the Commission find it should make changes elsewhere in its rules based on the evidence herein, it is requested that it do so, and make any other modifications it finds to be just and proper to serve the public interest.

2. Documents presented may help expedite requested evaluation by federal health agencies

2.1 Reasons to ask the federal health agencies to evaluate presented material

- Since the Commission has stated it does not have the expertise to evaluate the evidence and claims pertaining to RF biological and health effects which the Ad-Hoc Association and other parties in this proceeding have presented to the Commission, and
- since the Commission stated it defers to the federal health agencies which have participated in this proceeding, and,
- since the Commission *does* have responsibility for appropriately setting its exposure criteria,

therefore the Commission should ask aforementioned federal health agencies to evaluate with specificity each study or experimental finding included in the enclosed documentation, and noted below, and to indicate to what extent such studies and findings support the requests made both (i) in the petitions for reconsideration of the Ad-Hoc Association and as clarified in the Ad-Hoc Associations ex parte submissions, and (ii) and in the petitions and clarifications of other parties in this proceeding making requests that the Commission's rules provide greater protections from RF health related effects. Please contact the Ad-Hoc Association if the Commission or any parties reviewing this document are unable to find referenced materials or have questions.

Moreover, the Commission has a responsibility to seek advice from the federal health agencies with expertise on this matter, especially the Environmental Protection Agency (EPA) since, under the Reorganization Plan No. 3 of 1970 EPA was charged with the authority to provide RF protection guidance for all federal agencies [see 42 U.S.C. 2021(h) (1986), and reference in Federal Register, Vol. 51, No. 146, July 30, 1986 pg. 27318].

2.2 One set of documents to Chairman:

Insofar as the Commission has stated it does not have the expertise to evaluate RF biologic and health related matters, the Ad-Hoc Association is providing only one set of copies of documents to the Chairman of the Commission (with appropriate original and copy to the Secretary). In this

way, the Commission may expedited the evaluation by the federal health agencies described in 2.1 above. Also, the Chairman may make these documents available to those in the Commission who may wish to review them.

3. Documents presented, showing Exhibit Number:

#E101: Report commissioned by the Spectrum Management Agency of Australia from the Australian Commonwealth Scientific and Industrial Research Organization (CSIRO) on: Status of Research On Biological Effects and Safety Of Electromagnetic Radiation: Telecommunications Frequencies, by S.B.Barnett, June 1994.

This is a very significant document pertaining to the requests of the Ad-Hoc Association. The Commission should know that the Australian Spectrum Management Agency (SMA) which commissioned this study has a similar purpose and authority as does the Commission. The SMA is understood to have selected CSIRO to make a report the above report because of its expertise and relative independence from industry influences.

The Commission is urged to review this document because, while the Commission has stated it does not have the expertise to evaluate the report, the report does make findings and raise concerns about non-thermal effects and which 'on its face' support Ad-Hoc Association requests. Therefore, by studying this report, the Commission may more clearly see that there may be a sound basis for the Ad-Hoc Association requests and therefore that the Commission should seek an evaluation by the federal health agencies, since they may have over-looked, misunderstood, or may not have been aware of recent studies noted in this report.

#E102: Radiofrequency Radiation Exposure Standards, Australia and New Zealand, 100 kHz - 300 GHz: A Case For Reducing Human Exposure Limits Based On Low-Level, Non-Thermal Biological Effects, by A. H. Doull, Australian Commonwealth Scientific and Industrial Research

Organization (CSIRO) Health and Safety Adviser, and Dr. C. Curtain, CSIRO Honorary Research Fellow, January 1994. This is an important document for the Commission to review because it is prepared by the CSIRO Health and Safety Adviser and by a CSIRO honorary research fellow. Moreover, they argue that the Australian standard which is constant at 200 microwatts per square centimeter should be made even more stringent. These arguments would also apply to Ad-Hoc Association requests that the Commission's rules be more stringent, since for frequencies above 300 MHz the Commission's standard is less stringent than the Australian standard which Drs. Duall and Curtain find not sufficiently protective.

#E103: "Potential and Actual Adverse Effects of Radiofrequency and Microwave Radiation at levels near and below $2 \mu\text{W}/\text{cm}^2$," by Dr. Neil Cherry, Department of Natural Resources Engineering, Lincoln University, New Zealand, February 28, 1997

Dr. Cherry's report is similar to the above other two reports, in that studies are cited indicating adverse effects at very low RF exposure levels - often being the same studies cited by exhibits E101 and E102. Since Dr. Cherry's report is dated this year, it reviews more recent studies and for this reason alone provides an important contribution.

Dr. Cherry also emphasizes that when there is uncertainty, whatever data that is available should be used to set exposure limits and that these should be set with caution - erring on the side of prudence when there is uncertainty due to study design, analysis or lack of sufficient replications. Moreover, Dr. Cherry proposes specific exposure limits, rather than just noting the need for caution or perhaps some unspecified more stringent limits as seems to occur in exhibits #E101 and E102. The Commission should note that the limits proposed by Dr. Cherry are similar to those proposed by the Ad-Hoc Association, and thus further supports the science based and public interest based requests of the Ad-Hoc Association.

#E104: "Microwaving Our Planet: The Environmental Impact of the Wireless Revolution," by Mr. Arthur Firstenberg, 1996. Mr. Firstenberg does not hold an academic degree in the area of RF health or biological effects and thus some parties may question his capabilities to prepare the review he published. In the review, Mr. Firstenberg notes he has three years of medical school training, providing some expertise in understanding biological effects studies. He also notes that he has been studying this area for 15 years.

One of the unique features of Mr. Firstenberg's review is his emphasis on Russian and Eastern and Central European studies that have been translated through the U.S. Department of Commerce Joint Publication Research Service (JPRS), some of them being recent, e.g. from 1986 and including studies as recent as 1996.

Because Mr. Firstenberg does not have the 'proper academic' qualifications to be considered an 'expert' the Commission is understandably and arguably justified in being wary of accepting any of his claims and interpretations (indeed for similar reasons the Commission may be wary of the claims of the Ad-Hoc Association). However, Mr. Firstenberg's background and, most importantly, because of the findings reported, his review cannot be ignored, but rather his interpretations of the referenced studies must be verified (and similarly for the Ad-Hoc Association). Because the Commission seeks to assure its limits are safe and are in accordance with the most recent scientific findings, the Commission therefore must determine if the claims of Mr. Firstenberg can be substantiated. Since the Commission has frequently stated it does not have expertise concerning RF health and biological effects matters and seeks to defer to the federal health agencies with such expertise, the Commission must ask such agencies to evaluate the studies referenced by Mr. Firstenberg, and to indicate to the Commission how these studies support the requests in the petitions for reconsideration of FCC 96-326 and FCC 96-487 made by

the Cellular Phone Taskforce and submitted by Mr. Firstenberg, its chair, and also how these studies cited by Mr. Firstenberg support the requests of the Ad-Hoc Association which have been made in this proceeding, including in its petition for reconsideration of FCC 96-326 and FCC 96-487.

#E86: Abstract of S. Kwee et al, "The Biological Effects of Microwave Radiation," given at the Second World Congress of Electricity and Magnetism in Biology and Medicine, in Bologna, Italy, June 8-13, 1997.

This abstract is provided to support the report by the Ad-Hoc Association in its July 7, 1997 ex parte submission that at a specific absorption rate (SAR) of RF energy at levels of 2.1, 0.21 and as low as 0.021 mW/kg of body weight that, *"It was found that cell growth in the exposed cells differed from that in the control and sham exposed cells and a decrease in cell growth was seen."*

An SAR of 0.021 mW/kg is equal to 0.000021 W/kg, which is about 1/19,000th of the Commission's hazard threshold of 4 W/kg. On the enclosed abstract, it is noted that by way of an oral report of a participant who attended the presentation (see enclosed abstract for details) that the SAR levels are known. Accordingly, the Commission may be appropriately wary and must request the federal health agencies to contact the researchers and to verify the exposure levels and other important study information and to evaluate the extent this yet unreplicated finding supports the Ad-Hoc Association requests and those of other parties in this proceeding concerned that the Commission's rules need to be made stringent.

Because of the extremely low value at which an effect on epithelial cell growth rates occurred, and since the Commission has not yet reached finality on this matter, the Commission must request and evaluation as requested in the above paragraph.

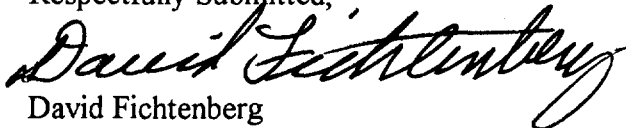
#E93: on some absorption characteristics of electromagnetic energy, from The New Encyclopedia Britannica, Vol. 18, 1991, pg. 198. The submitted information is relevant to considerations of RF exposure. If the vitreous humor of the eye has similar RF absorption characteristics as water, then the absorption characteristics provided in this exhibit would apply to the power densities to which the retina may be exposed by way of direct exposure (vs. reflections off the skull or other mechanism whereby 'hot spots' are generated.

4. Need to get evaluation of recent scientific findings:

In regard to the policy of the Commission to have its limits reflect the most recent scientific data, the Commission should note that the 1986 National Council for Radiation Protection and Measurement RF criteria referenced by the Commission in its FCC 96-326 Final Rule and Order, and upon which the Commission's limits are based, derive from studies with a publication cut-off date in 1982. Similarly, the RF standard of the Institute of Electrical and Electronic Engineers (IEEE) IEEE C95.1-1991 upon which the Commission's standard is also partially based, has a publication cut-off at the end of 1985. Therefore, even if the Commission may be wary of the findings in the above reviews, in order to have its RF health and safety rules reflect the most recent scientific findings, the Commission must ask that an evaluation be made of the RF health and biological effects studies, findings, and the petition for reconsideration requests which pertain to these findings.

Signature:

Respectfully Submitted,



David Fichtenberg

Dated: July 9, 1997

Spokesperson for the Ad-Hoc Association of Parties Concerned About the Federal Communications Commission's Radiofrequency Health and Safety Rules et al

PO Box 7577

Olympia, WA 98507-7577 Tel: (206) 722-8306

E101

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Status of Research On Biological Effects and Safety Of

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Electromagnetic Radiation: Telecommunications Frequencies

by S.B.Barnett

Ultrasonics Laboratory, Division of Radiophysics, CSIRO

June 1994.

A report commissioned by the

Spectrum Management Agency of Australia to be prepared by

the Australian Commonwealth Scientific and Industrial
Research Organization (CSIRO)



Spectrum Management Agency

Purple Building, Benjamin Offices
Chan Street, Belconnen ACT 2617
PO Box 78, Belconnen ACT 2616

Telephone: (06) 256 5555
Facsimile: (06) 256 5200

CSIRO REPORT ON:

**STATUS OF RESEARCH ON BIOLOGICAL EFFECTS AND SAFETY OF
ELECTROMAGNETIC RADIATION: TELECOMMUNICATIONS FREQUENCIES**

INTRODUCTION:

The CSIRO's report on *The status of research on biological effects and safety of electromagnetic radiation: telecommunication frequencies* was produced in 1994 at the request of the Radiocommunications Consultative Council's (RCC) consultative working group on electromagnetic compatibility and the side effects of radiofrequency emissions (both the RCC and working group are chaired by the Spectrum Management Agency (SMA)). The report was funded by the three telecommunications carriers, Optus, Telecom and Vodafone. On completion it was distributed to the Department of Communications and the Arts (DoCA) for consideration and subsequently to the Department of Human Services and Health (DHS&H) to assess the implications of the report and to achieve a coordinated response.

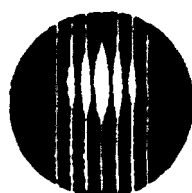
COMMENT:

In February 1995, The Minister for Communications and the Arts, the Hon Michael Lee MP wrote to the SMA requesting co-operation with DoCA and DHS&H in setting the direction for further research into both the health and standards issues arising from the CSIRO report. He also noted that, in view of possible community interest, he had no objection to the SMA releasing the report to the public. He also referred the report to the Minister for Health requesting that the relevant Departmental agencies coordinate their approach to further research, standards setting and enforcement activities. A copy of the report was distributed to the RCC working group at the first 1995 meeting at the end of March.

The SMA, in consultation with DoCA and DHS&H, has undertaken the following actions:

- The CSIRO report referred to the National Health and Medical Research Council (NHMRC) and Australian Radiation Laboratory (ARL) for assessment and advice on future directions for research and funding.
- Legal advice sought on the enforcement of Australian Standard AS 2772 - *Radiofrequency Radiation: Maximum Exposure levels 100 kHz to 300 GHz* - by the SMA (as part of licence conditions) and/or by State agencies.
- The CSIRO report made available to any member of the public, on request.

As part of its ongoing interest in the possible side effects of radiofrequency radiation, the SMA continues to consult with the DHS&H, particularly with respect to the development and enforcement of the appropriate standards in line with best international practice. The objective is to continue to ensure safe levels for both non-occupational (public) and occupational (transmitter site) exposure.



CSIRO
AUSTRALIA

Division of Radiophysics
Ultrasonics Laboratory

**STATUS OF RESEARCH ON
BIOLOGICAL EFFECTS AND SAFETY
OF ELECTROMAGNETIC RADIATION:
TELECOMMUNICATIONS FREQUENCIES**

CSIRO
Division of Radiophysics

**CSIRO REPORT ON THE STATUS OF RESEARCH
ON THE BIOLOGICAL EFFECTS AND SAFETY
OF ELECTROMAGNETIC RADIATION:
TELECOMMUNICATIONS FREQUENCIES**

June 1994

Prepared by S.B. Barnett, P.hD.

**Ultrasonics Laboratory,
Division of Radiophysics, CSIRO
126 Greville Street, Chatswood 2067.**

Contact: 61 29412 6009

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PREFACE

The CSIRO Report presents the current status of research on health effects of electro-magnetic radiation at frequencies relevant to telecommunications.

Because of constraints on time and resources, this report does not claim to be a comprehensive evaluation of the many hundreds of published papers and conference reports on the subject of biological effects of EMR. Rather than attempt to cover every aspect of biological effects research that has been published, it highlights what are considered to be important issues relative to human health. Because of the uncertainties in dosimetry and experimental procedures in many early studies this report has focused on relatively recent (within 10-15 years) studies to improve the chance of achieving consistency. There are a number of review articles that deal with pre-1980 research.

The CSIRO Report has been prepared in a way that will allow it to be read and understood as a single entity. Thus, it includes supporting information (in text and table format) for the summary statements thereby obviating the need to refer to other reference texts except for detailed information. The bibliography is provided as a means of identifying sources of information and a data base is being compiled. However, it should not be taken that this list is either comprehensive, or that every report has been scrutinised for its scientific validity. It was considered to be ethically appropriate to make comment on issues and to try to avoid overt criticism of publications that have presumably already passed some scientific peer-review process. Much of the recent data that was presented at the BEMS conference is not published in peer review journals and was not reviewed for acceptance at the conference. The relevance of certain fields of study has been questioned in some instances.

This CSIRO Report on the status of research on biological effects and safety of electromagnetic radiation was prepared by the Division of Radiophysics. A contribution to the cost of this project was provided by Spectrum Management Agency.

SCOPE OF REPORT

The possible adverse effects on human health of exposure to radiofrequency (RF) and microwave electromagnetic fields and radiation are of public concern. As the ambient electromagnetic environment continues to intensify (e.g. cellular and portable phones, wireless communications, LANs, PCNs) the effects of exposure from cumulative sources and prolonged exposure to low levels needs to be addressed. Advice is based on the assessment of risks to health resulting from these exposures as derived from studies on the effects of RF radiation on animals and volunteers and from epidemiological studies of exposed populations. This review considers RF and microwave radiation above 100 kHz. It is acknowledged that there are several possible areas of biological interaction which have health implications and about which current knowledge is limited.

The CSIRO Report draws information from: major reviews by scientific bodies (EPA 1984; NCRP 1986; NRPB 1991; NRPB 1992; NRPB 1993; WHO 1993), and the extensive scientific literature; interviews with prominent scientists in the USA, UK, Europe and Australia; interviews with government agency representatives in the USA and UK. Information was also obtained through attendance at the conference of the Bioelectromagnetic Society, 1994. The CSIRO Division of Radiophysics research program includes investigation of the biological effects and safety of microwave radiation. The CSIRO Report was prepared with support and resources provided by the Division of Radiophysics and a financial contribution from Spectrum Management Agency. Contributions from the Australian Radiation Laboratory constitute sections 11 and 12 of the report on dosimetry and epidemiology.

Because of the lack of information on the responsible mechanisms it is difficult to ignore the effects at low frequencies when reviewing the literature on frequencies used for telecommunications. However, this is beyond the scope of this report.

Microwave and Radiofrequency Radiation

This report refers to microwave and RF radiation. Microwave radiation borders on the optical part of the non-ionizing electromagnetic spectrum, ranging in wavelength between 1 mm (300 GHz) and 1 metre (30 MHz). Most of the animal experiments have been carried out at commonly used frequencies such as 27, 915, or 2450 MHz. Exposure are often carried out in the far-field (at distances greater than one wavelength from the antenna), where the magnetic and electric

components of the radiation are in-phase. Assessment of applied dosimetry is relatively straightforward compared to near-field conditions (as applied in the use of cellular telephones) although *in situ* tissue dosimetry is not fully understood. Radiofrequency radiation encompasses the microwave region and additionally extends to ELF frequencies where pulse modulation systems are employed.

Sources of human exposure to RF and microwave radiation include microwave communication links, radar, radio and TV transmitters and domestic microwave ovens. The strongest RF fields likely to be encountered by members of the public are those used in clinical magnetic resonance diagnosis which may involve patient exposure for short periods (less than 1 h) at whole-body SARs of up to about 4.0 W/kg.

RF and microwave radiation emits a waveform as oscillating electric fields (measured in volts per metre, V/m) and magnetic fields (amperes per metre, A/m). The intensity (or power flux density) of a beam of radiation is expressed in watts per square metre (W/m^2), equal to the product of the electric and magnetic field strengths. The rate of absorption of energy by biological tissue in animals or humans is conventionally described in terms of the specific energy absorption rate (SAR) expressed in watts per kilogram (W/kg) for the whole body or parts of the body. The time-integral of this (watts multiplied by seconds, per kilogram) gives the specific energy absorption in joules per kilogram (J/kg).

1.0 INTRODUCTION

A by-product of technological development is the recent rapid increase in environmental exposure to electromagnetic radiation, whether in the home, or in the workplace, or in public areas. The polluting signs of industrial development are visibly obvious air-borne or water-borne particles that obscure the air and clearly damage the environment. Electromagnetic radiation is even more pervasive and is unseen and unrecognised. Public concern is easily activated by a fear of the unknown. Terms such as "electromagnetic smog" have been coined which express concerns about its potentially polluting effects. Because of public community awareness and industry concern of the risk of litigation there is an apparent urgency to provide an answer to the question of safety of handheld mobile and cellular telephones. The use of these devices is unique in that the power transmitter is held against the head of the user. Media attention has focused on the legal claims for damages due to alleged cause of brain tumours. Public concern is aggravated by the appearance of multitudes of cellular transmitter antennas on towers adjacent to school playgrounds and on office buildings. Electromagnetic interference is already recognised as an important problem and work has begun to address issues on compatibility of electronic equipment. There are vital health issues associated with EM interference of medical equipment, but these are outside the scope of this document.

Issues that are critical for an assessment of human health effects are: teratogenic, mutagenic, carcinogenic/tumour production, ophthalmic, immunologic and neurologic effects.

There have been suggestions, based on some epidemiological studies at low (power line) frequencies that chronic exposure to EM fields may increase the risk of developing certain types of cancer. Although there has been no epidemiological study completed specifically addressing the higher frequency range used for telecommunications there have been some reports of increased incidence of tumours in animals exposed to microwaves together with a known carcinogen. However, there was a recent report of increased breast cancer in a very small group of female radio-operators on Norwegian ships (Tynes et al 1994) who were exposed to a combination of ELF and RF radiation. The recent legal claims in the USA that brain tumours may be caused by the use of digital cellular telephones has focussed the debate on the 450-915 MHz frequency.

For the development of cancer to be a significant issue it requires critical changes in development of certain cells that can be detected with appropriate tests. There are two aspects to cancer development; the production of aberrant cells and the depression of the body's natural immunological defences. Abnormal cell growth and behaviour may be detected as altered enzymatic activity, altered gene expression, peculiar growth patterns and changes in the ability of transformed cells to form colonies with *in vitro* tests. In cell biology, calcium plays an important role as a biochemical regulator that helps to relay signals from the cell surface (receptor site) to its interior. One effect of altered calcium function may be the increased activity of growth enzymes leading to uncontrolled cell proliferation and cancer. Therefore, research has focussed on this issue.

Cells that are actively dividing are at the greatest risk of induced abnormalities, hence the bone marrow and blood-forming system and the developing central nervous system are considered to be the most sensitive targets. Claims of cancers in these biological systems have been associated with most forms of energy deposition. High rates of cell division occur in the development of sperm cells and effects could produce either tumours or abnormal cells with subsequent impairment of normal fertilization processes.

The normal status of circulating lymphocytes, natural killer cells and macrophages is important in the control of disease processes, in general. Therefore, a number of studies has been directed towards the possible interference in the haematopoietic and immunologic systems by exposure to electromagnetic radiation. The cell membrane is considered to be sensitive to EMR interaction and, therefore, one would expect to see bioeffects in the immune response and gene expression.

Research methodologies in medical and biological sciences have gradually evolved from studies of entire organisms or organ systems and tissues, cells and the molecules that comprise living tissue. The move away from reporting phenomenological effects on a gross scale in living tissues has presented a far greater challenge to scientists to understand the chemistry of molecular and sub-molecular composition and interactions. This has led to the emergence of a new field of science, bio-electromagnetics, that proposes that biological organisation is based on physical processes at the atomic level that regulate the products of biochemical reactions.

Cells grown in culture exhibit characteristic abnormal behaviours and appearance that can be readily identified. The use of *in vitro* test systems allows

manipulation of the environmental conditions in which the cells grow and provides an accepted vehicle for investigation of the mechanisms responsible for physiological and morphological abnormality. Animal models are also frequently used to identify potential carcinogens. The disadvantages of animal studies are that they are long-term, expensive, and results can be influenced by species or strain sensitivity to certain tumours. Mapping the *in situ* dosimetry in whole animals is far more complex than for *in vitro* exposures in radiation transparent cell chambers. The importance of animal studies is that they provide a complete biological system with which to evaluate the overall effect of subtle changes observed in cell systems. They allow closer relationship to the human's whole organism physiology with the advantage that their environmental conditions can be controlled to isolate the effects of an individual physical or chemical agent.

Clearly no single biological system will provide the answer to a problem as complex as the possible development of cancer from exposure to EMR. Any report, whether positive or negative, needs to be independently verified in a laboratory with similar scientific credentials before the result can become part of a reliable data base. Phenomenological approaches that report cause-and-effect events have limited usefulness. Predictions about safety can only be made with confidence when the responsible mechanisms are understood and demonstrated. The issue of safety of EMR in telecommunications is extremely important, socially and economically, however, it would be unrealistic to expect a definitive answer in the short term.

The purpose of this CSIRO Report is to review the existing literature and identify issues that are directly relevant to human health. It includes conclusions on the current status of international research and make recommendations on the direction of future research.

2.0 SUMMARY OF STATUS OF RESEARCH ON HEALTH EFFECTS OF EMR

2.1 EXECUTIVE SUMMARY

Key Points:

- Despite rapidly developing markets, there has been little funding for research on safety
- Accepted thermal effects above 1°C temperature rise
- Increasing evidence of non-thermal effects
- Cancer related effects are imotive issues
- Other important issues are corneal lesions, impaired memory function, and altered blood-brain barrier
- Dosimetry is uncertain, but numerical techniques are improving
- Past research lacks direction and the general standard of publications is not high
- Concerns over the suitability of the ANSI Safety Standard
- Lack of confidence in the value of epidemiology surveys

While this report deals with a wide range of frequencies relevant to telecommunications, it is obvious that there is a considerable emphasis on safety issues relating specifically to cellular telephones.

Digital technology has allowed unexpectedly rapid growth in the cellular telephone industry world-wide. According to Motorola (BEMS 1994) the number of subscribers worldwide increased from 25 million in 1992 to more than 34 million by 1993. Research on biological effects and development of safety standards always lags many years behind technological development, due to the limited availability of funding. However, public acceptance can be easily damaged if the safety issues are not satisfactorily resolved. A small proportion of the massive manufacturing benefits would fund substantial research programs.

To answer the question of safety of CT is a tall order. The vast majority of the research on EMR has addressed power line frequencies because it is an area of continuing public concern and has huge investment capital. Work in the microwave field has experienced bursts of activity mostly with the development

of microwave ovens, radar and radio communications. Generally, exposures used continuous wave. Data from ELF work shows that for many biological responses the waveform needs to be pulse-or amplitude-modulated. Subtle cellular effects of RF and microwave exposures are often dependent on pulsing and the presence of an ELF component in the waveform.

The main topic of concern seems to be whether or not a real risk exists for the development of cancer. This is doubtlessly due to the continuing uncertainty about power line frequency. Some evidence has been given for an association of leukemias and tumours with ELF fields and a recent report of increased breast cancer in female radio-telegraph operators. Many laboratory studies show abnormal cell growth and gene expression when exposed to ELF or RF modulated with an ELF component. The lay-press ignores any distinction of effects across the radiation frequency spectrum and implies a cancer link. From the perspective of human health implications, the key issues are whether there is any association with teratogenic, immunologic, neurologic, or mutagenic effects. There is a strong chance that the pre-occupation with cancer-related effects will drain much of the research resources in animal and epidemiological studies, without settling the debate. In the meantime there are other important areas of study that may be overlooked.

In the present climate of scientific uncertainty it is difficult to see how the situation can be suitably resolved in the near future. There is no scientific basis to support initiation of cancer by RF radiation and most human cancers take many years to develop. The latency factor is an important issue. Meaningful animal studies require exposure throughout the normal lifetime and therefore require many years to properly plan, exercise and evaluate. There is no evidence that low levels of electromagnetic radiation at frequencies up to 300 GHz can directly alter the DNA genetic material of cells and initiate cancer. However, there is some evidence that EMR alters enzyme synthesis in ways similar to known chemical cancer promoters.

The thermal mechanism is most commonly accepted, and there is a tendency to assume that physiological effects cannot occur in-conditions where the expected temperature increase is less than 1°C. Reports of teratogenicity, altered behavioural responses, and lens cataracts are usually associated with a significant increase in tissue temperature caused by high SARs. There are some reports of synergism between different radiations. The attitude of physical scientists is, generally, to disregard reports of effects for which a known physical mechanism

cannot be readily attributed. However, the mechanisms are inadequate to explain all of the observed biological responses. Radiation biologists have reported a number of changes in various biological systems following exposure to EMR that produces insignificant or undetectable, temperature increase. These effects range from alteration of ion concentration in cells, increased rate of DNA synthesis to enhancement of the rate of tumour growth in experimental animals. The effects have been reported over a range of frequencies from ELF to RF. Mechanisms for many of these biological effects have not been identified or proposed and this lack of scientific explanation has, not surprisingly, led to a reluctance to accept the effects as "real". The difficulty is compounded by the fact that as there is limited research activity, particularly at RF, much of the work has not been replicated in independent laboratories. There is often no attempt to establish a dose-response for reported effects. This is difficult to explain or justify.

Whilst researching the scientific data base in the preparation of this report it has become evident that subtle changes in cell structure and biochemistry have been frequently reported at exposure levels where gross thermal change could not be attributed as a cause. The effects involve a number of phenomena from cell membrane permeability to altered gene expression. For a cellular alteration to be permanent requires alteration of the DNA or synthesis or activation of specific genes. Epigenetic postulates have been developed for cancer induction as alternates to the existing DNA breakage mechanism in mutagenesis. Cell membrane receptors mediate transmembrane ion flow and signal a cascade of intra-cellular biochemical events that culminate in altered gene expression and erratic growth patterns.

A number of effects have been reported from reliable research groups of *in vivo* effects resulting from exposure to pulsed microwave radiation. Reported low level *in vivo* effects that have received little notice involve the impairment of short-term memory function in rats exposed to 2.45 GHz at 1 mW/cm² or whole body SAR 0.6 W/kg for 45 min. The effect was produced with both c.w. and pulsed waveforms and is thought to be due to microwaves activating endogenous opioids in the brain thereby causing a decrease in cholinergic activity in the hippocampus. The effect is similar to that caused by stressors.

Degenerative changes have been reported in ocular tissues in primates exposed to pulsed (1.25 - 2.45 GHz) microwaves where SAR 2.6 W/kg has produced lesions in the cornea and iris. Application of the glaucoma drug timolol maleate